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ESSAY

ON THE

HYDROGRAPHY

OF THE

MERSEY ESTUARY.

BY

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LIVERPOOL:
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PREFACE.

THE collection of the materials from which the following pages result, was undertaken at the commencement of the past winter, under the idea that the then contemplated changes in the Authorities of the Port would furnish a fitting occasion for submitting to them a Report upon the past and probable future condition of the Estuary. As the time of those changes approached, it became evident that the original purpose could not be accomplished in a form sufficiently condensed for reading at the sitting of a Board or Committee, and the work was pursued with the view of preparing a paper for one of the local scientific societies; but when completed, conceiving it perhaps too lengthy for that purpose, and that the subject on which it treats is one of more especial interest to the authorities in whose service the author is engaged, the manuscript was submitted to the Marine Committee of the Mersey Docks and Harbour Board, with a request, seconded by the Marine Surveyor, that it might be printed for private circulation. The illustrations are on a scale too large for publication, but will be gladly exhibited by the author; and if the treatment of the subject should be found to possess sufficient interest, they can be readily reduced to a convenient scale for a small Atlas to accompany the Essay.

GRAHAM H. HILLS.

LIVERPOOL, 12*th May*, 1858.

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ESSAY

ON THE

HYDROGRAPHY

OF THE

MERSEY ESTUARY.

AMONG the many points of interest concentrated in Liverpool, none surpass in importance those arising from considerations connected with the history of her port. Dating her commercial greatness from a recent period, our cognizance of its capabilities and disadvantages has gone hand in hand with her advance in commercial prosperity, and the consequent demands of nautical traffic: hence, in tracing the hydrography of the Mersey, our researches are baffled at a date comparatively recent by the failure of authentic records; anterior conditions being evidenced through collateral sources, until, in the receding vista of time, our vision is lost amidst speculations involving geological conditions belonging to an earlier era of the world. Chorographic descriptions, leading up to England's earliest historic ages, leave no other inference than that such as it now appears it then existed. The first light of history dawning upon the scene, shows the ancient tide, in solitary majesty, rolling on these silent shores, and the first germ of this vast city planted beside its waters, near 800 years ago, presents to our view the same grand natural features which now we witness.

Those features consist of a large inland basin, fed by tributary streams, issuing through a narrow gorge into a bay of the sea; whose shores are fringed with banks of sand, alternately covered and uncovered by the reflux of the waters, as indicated in the chart of modern date (Sheet 1), where the entire coast from Ormeshead in Wales, to St. Bee's Head in Cumberland, is seen with its sandy border, broad towards the central portions, narrowing toward the extremes, and aggregating in every inlet and indentation of the coast; such, too, are the features exhibited in the small chart (Plan I. Sheet 2,) extracted from the earliest existing authentic hydrographic records of our coasts, and bearing the date of 1687. Our history previously to this must be gathered from incidental mention, in connection with places and circumstances belonging to the neighbourhood, as no records of those times, strictly hydrographic, have come down to us.

At the date just named, Liverpool had already attained a prominent position as a commercial port, chiefly from its trade with Ireland, and there were in all probability then extant hydrographic delineations of its port, but of a rude description, such that even, if preserved to us, it is doubtful if they would have contained any but that general information which we derive from other sources, and would not have been susceptible at this time of critical examination. This will be apparent when it is remembered that it was only towards the beginning of the seventeenth century that hydrography was reduced to any thing like a science. About the year 1550, the mode of projection which still bears his name first occurred to and was adopted in "An Universal Map of the World," published by Gerard Mercator; but it was an English mathematician, Mr. Edward Wright, who first applied it to sea charts, and reduced the principle to a mathematical law, which he gave to the world in a treatise published in 1599.[1]

The earliest existing authentic hydrographic delineations of the Mersey estuary we have referred to, are found in a work entitled "Great Britain's Coasting Pilot,"[2] published in folio, in London, in 1693, by Captain Grenville Collins, R.N., hydrographer to the King. The one already particularised is a general chart of the coast. Another, No. 30 in the same work, also dated 1687,

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[1] *Phil. Trans.*, 1765 to 1763, p. 218; "Correction of certain Errors in Navigation, exemplified in the Voyage of the Earl of Cumberland to the Azores." By E. Wright, 1599.

[2] A perfect copy of the original edition of 1693 is in the Liverpool Library, at the Lyceum, Bold Street.

(Plan II.), placed on Sheet 2, beside the former, is on a considerably larger scale. They both belong to a series comprising the coast of Great Britain, from Shetland down the east coasts of Scotland and England, the English south coast, and the Bristol and Irish Channel coasts, with some ports in Ireland. Since 1599, a period had intervened which in this country was one of frequent political and social convulsion, tending to hinder our advance, and to give to other maritime people opportunity to surpass us in the development of maritime science,—illustration of which is found in Captain Collins's preface, where he states that the work was undertaken by order of King Charles, moved " by his great love for the noble art of navigation, and his being made aware that there were in existence only Dutch charts of our coasts, or copies of them, and those very incorrect;" and his Majesty having given the author the command of a yacht for the purpose, we are informed in another part of the work, that he completed the survey in the following order:—In the years 1681-2, Dover to the Land's End; 1683, the Islands of Scilly, the Severn, and Milford Haven; 1684, from Harwich to Edinburgh; 1685, from Edinburgh to Orkney and Shetland; 1686, from Milford to Chester; 1687, Liverpool, Carrickfergus, Dublin, Kinsale, and Cork. This sequence, in which we find Liverpool among the last, is interesting, as showing to some extent, by the order of the work, the relative importance probably attached to the several subdivisions of the survey; and also as a proof of the critical value of the work, in evidencing its methodical arrangement. In this view, the time occupied relatively to the magnitude of the undertaking, and the means available in its progress, are requisite to be taken into account. Also, it is important to note the object proposed by the author himself, which he conveys to us in his preface, where it is stated, " the intent of this survey is *only* to give directions to mariners to sail along the coast of Great Britain, and how to carry a ship into any harbor, river, port, road, bay, or creek, with safety; and how to avoid *dangers known.*" I have italicised the words " only " and " dangers known," because, while limiting his purpose, they partly indicate the method to be pursued in the execution of the work, which would consist, not in a minute search for unknown dangers, but in testing certain depths of water, in verifying the position of known dangers, and the direction of leading lines and clearing marks by the compass, which as yet formed the best resource for trigonometrical measurements at sea; and, lastly, in collecting information by local inquiries. The reliance placed upon the latter is shown, where Captain Collins gives as a reason for not having surveyed the entrance of the Thames, that pilots were there so numerous that it would be more safe to trust to their guidance, thus permitting local information to supersede the necessity for a survey. This, of course, was not the only consideration that weighed with him: another, doubtless, would be, the comparative benefit to be derived from the more speedily completing the survey of other ports where pilots were deficient. Again, in another place, he prefaces a table of Bearings and Distances with, "Courses and distances are better demonstrated in mapps than this way; but at the instigation of some seamen I have done this."

In the original of the chart (Plan II.) the whole of the river Dee up to Chester is included. I have omitted so much as was beyond the confines of our subject, but scrupulously preserved that relating to the Mersey estuary. In the chart, the Mersey is necessarily introduced, from its position, approximate to the Dee; similarly, in the descriptive portion of the work, the mention of the Mersey is only incidental or secondary: thus, in connection with Hoylake,[1] it is stated that "Here the great ships that belong to Liverpool put out part of their cargo till they are light enough to sail over the flats into Liverpool. There is a channel near Formby to go into Liverpool, where is three fathoms at low water; but this place is not buoyed nor beaconed, and so not known. The ships lie aground before the town by reason of the strong tides that run here; ships that ride afloat ride up at Sloyne, where is less tide."[2] This quotation, with one leading line for sailing through the Rock channel, is the whole information given respecting the port of Liverpool.

Turning from the natural features, it will be observed that the only artificial aid to navigation shewn on this chart is the Rock Perch, occupying the site of the present Rock Lighthouse.

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[1] Spelt Highlake.

[2] A marginal note is appended in the original: "King William (III.) and the English army embarked at this place (Highlake) for Ireland."

In 1709,[1] twenty-two years subsequently to the date we have been considering, was obtained the act of Parliament under the authority of which was commenced the first of the Liverpool docks, and which conferred on the Liverpool corporation powers to erect landmarks and to place buoys in the channels. Eight years later (1717), the money raised for these works being spent, the dock yet unfinished, and no beacons nor buoys having been placed, another act was passed granting an extension of powers, the corporation undertaking at the same time to place two landmarks and three buoys in or at the entrance of the Formby channel, and two buoys on the Hyle sand, one at the N.E., the other at the N.W. spit of that bank, and to complete the buoying and marking of the channels by 25th December, 1718. The execution of this undertaking must have concentrated inquiry upon the estuary, and it would have been expected that an authoritative record of its then condition would have been handed down to us, especially that the completion of the buoying and landmarks would have been indicated by a fresh survey. My inquiries have not detected any hydrographic records relating to this interesting period; and it seems probable that, as previous undertakings respecting the docks had failed in regard to time, so perhaps the completion of this may also have been deferred for some years.

In 1730 a chart was published in London, having the following title, "A Correct Chart of the Harbors of Chester and Liverpool: humbly dedicated and presented to Joseph Taylor, Esquire, member of y^{e} Hon^{ble} House of Commons, by his obliged and humble servant, C. Price."[2] This chart presents no evidence of the progress of the undertaking respecting the Formby landmarks, and, on inspection, proves itself worthless as a record, being a veritable copy from Captain Collins's chart, scarcely disguised by unartistic embellishment. The sailing directions appended are word for word those quoted from *Great Britain's Coasting Pilot*, as to the "great ships unloading" in Hoylake and Formby channel being unknown.

[1] Baines's *History of Liverpool*, p. 400.

[2] An original is in the Corporation Surveyor's office, Town-hall, Liverpool.

In 1738 appeared the work of Messrs. Samuel Fearon and John Eyes, entitled, " A Description of the Sea-coast of England and Wales, from Black Comb in Cumberland to the Point of Anglesea in Wales, &c., according to actual survey made thereof during the years 1736-7."[1] It was published in Liverpool; the accompanying charts bear the name of Emmanuel Bowen, engraver, of London; he was a noted map-publisher, and Geographer to the King. He attests, in a subsequent work, to the circumstances under which the survey was undertaken. He was author of a series of maps of the counties of England, divided into hundreds; on one, of the county of Lancashire,[2] apparently belonging to this series, is a note on Liverpool, to the effect that, in consequence of the dangerous sands about its harbour, the gentlemen and merchants of the corporation and neighbouring county raised a large subscription to defray the expense of a survey to be made by land and sea, and intrusted the execution of the work to Messrs. Fearon and Eyes: in the work itself is given a list of subscribers' names. It received the sanction of high authority: it being stated in the preface that "it hath been referred for examination to the Right Hon. Sir Charles Wager, First Commissioner for executing the office of Lord High Admiral, &c., &c.; approved by the Master, Wardens, &c., of Trinity House, London, and by other eminent mathematicians, Fellows of the Royal Society.

We perceive in it a marked distinction from the survey before considered, in the time they respectively occupied, two years having been devoted to this comparatively small portion of the coast; and, on examining the work, we find a proportionately detailed description of all parts included in it. Liverpool Bay, instead of being despatched in a few lines, has devoted to it eight quarto pages of letterpress. The authors affirm theirs to have been the first survey executed with instruments other than the magnetic needle. In this they allude probably to the use of Hadley's quadrant or sextant, then recently introduced to the world,[1] an instrument which stands perhaps second only to the compass in the influence it has had in promoting the science of navigation, and which, to the nautical surveyor, is second to none; originating in the idea of Dr. Hooke,[2] and perfected under the supervision of Newton,[3] it was presented in a practical form to the Royal Society, by John Hadley, in 1731. The invention would afford to Messrs. Fearon and Eyes facilities for trigonometrical measurements afloat before unknown, and enable them to attain to a degree of precision previously impossible; the degree may be in some measure appreciated by inspection of the chart (Plan I., sheet 3), where we perceive the stations at which soundings were taken, greatly multiplied in comparison with those shewn by Captain Collins; and the sand-banks, instead of appearing as unbroken symmetrical masses, are cut up by gullies in a manner obviously more true to nature. To apprehend perfectly the amount of accuracy attained, acquaintance with the methods pursued in the work would be requisite, and this can only be arrived at in part, negatively, by noticing scientific improvements afterwards introduced. Nearly thirty years subsequently, so little progress had been made in the use of Hadley's quadrant, that in the abridgment of the "Phil. Trans.," vol. 1763-9, is a paper on the subject by the Rev. John Mitchell, B.D., F.R.S., who thus writes—"The use of Hadley's quadrant, to take altitudes at sea, is already so well established that it wants no further recommendation, but there are several other purposes to which it may be applied, which, though obvious enough, seem yet hardly sufficiently attended to;" as one of these, he then instances that for surveying sands in harbours it is particularly valuable, and proceeds to recommend for its application a method which required an observer at a station on shore to act simultaneously with the observer afloat. Although the writer proves himself to be acquainted with the geometrical principles involved in the now common method of plotting afloat, from a deficiency of the necessary instruments, he was unable to recommend such a system. It is probable, then, that the practice resorted to by Messrs. Fearon and Eyes, thirty years before Mr. M. wrote, would be even more cumbrous than that he recommends. Plan I., Sheet 3, is a fac-simile of so much of their chart as refers to the Mersey estuary; it exhibits the landmarks and buoys authorized by the act of 1717, before quoted. They consisted of two circular towers at Formby, built of brick, and tapering towards their summits: the south-eastern one nearly 100 feet high, situated on the south bank of the river Alt, the tide at high-water washing almost to its base. This tower still exists, and recently was in use as Formby lighthouse, though now standing at some distance inland, a change which has been effected by natural causes, tending to the progressive increase southward of the sandhills lying to the westward of it, aided artificially by works erected for the conservancy of the river Alt, and neighbouring lands.[1] Nearly a mile to the north-westward stood the other, somewhat less in height than the former, its site still easily discernible by its ruins. There also appear two buoys in Formby Channel and two on Hoyle Bank, and a landmark, seemingly a timber erection, at Hoyle Lake. The effect of these aids to navigation is thus described: "These (Formby) marks are a great height, and frequently seen from the back of Hoyle, or to the westward of the N.W. Spit; and farther from the northward, if the weather be moderately clear, about the flats they seldom fail of being seen, except the weather is very dark, and not fit to come in with the land * * * and it may justly be said, the coming into the port of Liverpool is now very safe and easy, as Chester Bar, through the Horse, and up the Formby Channel are now truly described, and well buoy'd and beacon'd, with this advantage in respect of situation, that in most winds a weather side and smooth water may be chosen to come here with safety, which is the greatest security and encouragement a person can expect where he is not well acquainted." The authors indicate the sources whence they derived their local information, by giving a list of the names of pilots who assisted them in their work; among them we have a mention of Liverpool pilots. Their look-out station is described as Helbre Hole, a hollow still existing in the eastern side of Helbre Island, "whence, if weather permits, they beat out to meet vessels, either toward Chester Bar, or to the westward of the New Buoy and West Spit of Hoyle, where they often keep plying off, ready to board any vessels that choose to take in pilots, which few here refuse except some coasters."

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[1] A perfect copy of the original edition of this work is in the Library of the British Museum; a copy of the chart in the Free Library, Liverpool. Binns's collection, vol. 11.

[2] Free Library, Liverpool. Binns's collection, vol. 11.

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[1] *Phil. Trans.*, 1731, p. 486.

[2] Robert Hooke, M.D., F.R.S, an eminent philosopher and mathematician, born in the Isle of Wight, 1635; died, 1702.

[3] *Geometrical and Graphical Essays;* containing a description of instruments used in civil and military surveying, &c. By George Adams, London, 1791; p. 243.

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[1] The earliest Act granting powers for the conservancy of these lands, was passed in the year 1742. Its principal provisions related to regulations for planting a species of grass, called star grass, among the sandhills. This practice, then instituted, continues in force, and has contributed to the seaward advance of the shore in that neighbourhood.

In the history of Liverpool itself this also was an epoch, the latter year of the survey corresponding with the passing of the Act of Parliament, which authorized the erection of a jetty into the river from the entrance of the old dock, and the building of the second of the Liverpool Docks, called the Salthouse Dock.[1]

In 1755, Mr. John Eyes, the same person who was concerned with Fearon, in the survey last described, published an amended survey of the port, with sailing directions (Sheet 4). The major portion of the work was a reprint of the former edition, adapted in a few particulars to the requirements of the new survey, which comprehended only a small portion of the former, the parts to which it was directed are thus described: "The material alterations that have happened in the channels and banks, particularly in Chester water from Hoyle Lake to Liverpool, both through the Inshore deep and Spencer's Gut; also the depth of water in the Formby Channel and the New Channel, running through Burbo to the north end thereof, have been carefully surveyed, with the assistance of Edward Sumner, pilot, in the year 1755." Hence the alterations in the chart refer only to a part of the estuary of the Mersey, the remaining portions appearing in this edition with their original titles and dates.[2] And of the parts named above as having been surveyed, Hoylake remains unaltered in the chart, and the sailing directions given for Helbre Swash and Hoylake are the same as before, with the same remarks as to tidal currents. Considerable changes are evidenced in the neighbourhood of Spencer's Gut and the Rock Channel; but the most important occur near the north end of Burbo, in the appearance of a "New Channel," and the silting up of that part of Formby Channel between the Middle Patch and Burbo Bank.

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[1] Opened for traffic, 1753. Annals, *Gore's Directory.*

[2] A copy of this edition is in the possession of Mr. Joseph Boult, architect, &c.

In 1761[1] an Act of Parliament was passed, constituting the Corporation of Liverpool, the "Trustees of the Liverpool Docks and Harbour," authorizing the construction of a new dock, now called George's Dock, and granting powers for the erection of lighthouses, in the entry of the port, and for the collection of dues for the same, the light dues not to be receivable until the completion and exhibition of the lights from four lighthouses on the Cheshire shore, such to be within one mile of high watermark.

The earliest date at which we find mention of them as completed is in a chart, entitled, "The Coast adjacent to Chester and Liverpool, from the river Vorrid in Wales to the Ribble, by Murdoch Mackenzie, sen., surveyed in 1762," a fac-simile copy of which is in the Corporation surveyor's office. It represents the arrangement of the Cheshire lighthouses as they now exist, although that arrangement was only completed by the building of Bidston lighthouse in 1771 (Sheet 5). Murdoch Mackenzie having made and published at his own expense a survey of the Orkney islands, was employed under the authority of the Admiralty to survey the west coasts of England and Scotland, and the coast of Ireland.[2] The results of this extensive survey were published in 1776, in a series of thirty-one charts of the English and Scotch coasts, and twenty-eight of the Irish coast, accompanied by two folio volumes, containing descriptive matter and sailing directions. Chart No. IX.,[3] of the first series, includes Liverpool, and extends from Ormeshead in Wales to Formby Point; in so much of it as is included in the copy above mentioned, the two are identical, the latter is without date, except that of publication, 1776. From the dates[1] given, with astronomical observations made by the author at Holyhead and the Isle of Man, and with measurements for a base line on Formby and Crosby sands, there is no doubt that this portion of the coast occupied him in 1760 to 1762. But, in the descriptive part of the work, it is stated that the "above buoys and directions are agreeable to a survey taken in 1771;" hence we assume that the survey, so far as determining the contour of the land, was executed about the earlier date, and that the work afloat was subject to revision down to 1771, the lighthouses having been added while the work was yet in progress, according to the order of their completion. The authority under which this work was executed gave to it a degree of consideration which was partly justified by the measures related to have been adopted for its execution;[2] but it is probable that the merits of the different portions of the work were very unequal, as a part relating to the western islands of Scotland became afterwards subject to just stricture.[3]

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[1] Baines's *Liverpool*, p. 429.

[2] *Justification of M. Mackenzie's Survey of the Orkney Islands and Hebrides.* London, 1785. Copy in British Museum.

[3] *Chart of the Coast, from Ormeshead to Formby Point.* An original copy in the Hydrographic Office, Admiralty, London.

[1] A copy of the letterpress portion of the work, without charts, is in the Library of the British Museum. The references to astronomical observations, measurements, &c., are prefatory. The descriptive portion relating to Liverpool Bay, in the body of the work, pp. 14 to 17.

[2] The operations for the measurement of two base lines, of four miles in length, on Formby and Crosby sands, with a "substantial iron chain fifty feet long," are described.

[3] In 1783–4, James Anderson, LL.D., an eminent agricultural and statistical writer of the day, was employed by government to proceed to the western coasts and islands of Scotland, where the inhabitants were then labouring under severe distress, to inspect and report upon the resources of the country. The results were published in *An Account of the Present State of the Hebrides and Western Coasts of Scotland*, &c.; being the substance of a report to the Lords of the Treasury, published in Edinburgh, in 1785, by Dr. Anderson. Herein, among other recommendations, the necessity of a more correct nautical survey of the region is urged; and the author, having previously stated that he had taken *Mackenzie's Survey* for his guide, the recommendation was considered, by Mackenzie and his friends, as an aspersion on his work; who, therefore, published a "Justification," *vide* note, page 16, followed by a newspaper correspondence between the parties. The Justification consisted mainly of a series of circulars forwarded to different seaports. They attested; in a general way, to the accuracy of Mackenzie's charts, and the signatures of masters of ships, pilots, and others interested, were procured to append to them. Dr. Anderson had, however, made seven special allegations of inaccuracies, which were left untouched by the general attestations; and some of them

The copy from which the chart referred to in the Corporation surveyor's office was derived, was, in all probability, a publication subsequent to that of the general work, compiled in a form suitable to the requirements of the port of Liverpool; whatever care may have been bestowed upon the land measurements, the work afloat appears to have been of a cursory nature, only the channels having been sounded, and, from the insertion of alterations current while the work was in progress, the dates due to the several portions of the chart are involved in some ambiguity.

In 1767, John Eyes published a second emendation of his chart, (Sheet 6,) with sailing directions,[1] from a survey made in the same year; like his last, of 1755, it extended only to parts of Liverpool Bay, the remaining portion of the work being a re-issue of the original of 1737. The principal changes noted are the silting up of the new channel of his last survey, and the reduced depth in Hoylake; it will be observed that the survey of 1755 took no notice of any decrease in depth there; although bearing a date subsequent to M. Mackenzie's survey, this must be considered our earliest intimation of the positions of the lighthouses erected on the Cheshire shore under the provisions of the act of 1761.[2] They are two at Hoylake and two on the shore near Mock-

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have been proved against Mackenzie, by the results of Admiralty surveys now in progress. The correctness of the Liverpool survey does not appear to have been impugned; but amongst the general attestations of correctness is one from Liverpool, bearing twenty-three signatures, among which is not to be found that of Mr. Wm. Hutchinson, then the dock-master—an omission having some significance. A special attestation, also from Liverpool, is subjoined as a curiosity—"These are to certify whom it doth and may concern, that Robert Stewart, master of the *Lady's Adventure,* nor any of my ship's company, was ever at Liverpool before; and, by the assistance of Mr. Mackenzie's draughts, and nothing else but God's blessing, went clear of every danger."

[1] A fac-simile of the chart is in the Marine Surveyor's Office, Liverpool; and a copy of the letterpress in the possession of E. Eyes, Esq., of Nantwich, Cheshire, who is descended from the author.

[2] Act 2nd, Geo. III., cap. 86, 4th clause: "and there being at present no lighthouses or other lights erected and set out." * * * "And whereas there is not any proper fund provided for answering the good purposes aforesaid." These clauses show that lighthouses could not have existed before this time.

beggar,[1] the former leading into Hoylake, the latter into the Horse Channel. The inshore or upper light at Hoylake was exhibited from the lighthouse still existing there, which was partially destroyed by fire, July 15, 1765.[2] The present lower Hoylake lighthouse is of more recent date, the first having been a wooden structure. Of those near Mock-beggar, the inshore one was that now existing at Leasowe,[3] the outer one stood close to high watermark, the terms of the Act of Parliament compelling their erection within a mile of that limit.

Another chart, by P. P. Burdett, dated 1771, was published in 1774, in Messrs. Perry and Enfield's *Essay towards a History of Liverpool* (Sheet 7). Burdett was probably a land-surveyor and draughtsman,[4] employed by the originators of the work ; from the nature of such an undertaking, it was scarcely possible that, as a survey, it should be other than of a very cursory nature ;[5] and it bears internal evidence of being to a considerable extent a compilation.[6] Its date corresponds with the opening of George's Dock, commenced near ten years before, and the erection of Bidston lighthouse,[7] completing the system of lighthouses on the Cheshire shore as they now exist ; with Bidston appears only one lighthouse, at Leasowe. Local tradition affirms the existing Leasowe lighthouse, as well as Hoylake, to have suffered by the calamity of fire;[1] and it was probably when thus disabled, that Bidston lighthouse was built as an improvement and substitute; for at this date (1771) Mackenzie describes the sea lights thus:—"There are two lighthouses on the shore, to direct ships through the Horse Channel; one of which is moveable, and stands near Mock-beggar; the other, on the top of Bidston Hill." This moveable lighthouse, a timber erection, would then answer to the old Leasowe lighthouse, commonly reported to have been washed away.[2] The inshore tower, disused perhaps for a time after having been burnt, was restored, and became, in conjunction with Bidston, the outer of the sea lights, either at the time of the reported disappearance of the moveable lighthouse, or, possibly, superseded the latter previously to its final catastrophe.[3] It will be observed, that in Eyes's Chart of 1767 they are described as *lamp lights*,—marking the era of the introduction of lamps and reflectors in contradistinction to the beacon-fires hitherto in customary use.[4]

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[1] The Act of Parliament of 1761, provided that no dues should be collected until lights were exhibited from four lighthouses on the Cheshire shore (clause 31) ; and it appears, by the table of receipts of lighthouse dues, given in *Perry and Enfield's Essay towards a History of Liverpool*, that the dues were first collected in 1764. In a treatise on naval architecture, &c., published in 1774, by Wm. Hutchinson, at page 197 it is stated, " there were no lighthouses until the year 1763, at which time four lighthouses were erected—two large ones, called the Sea Lights, leading through the channel out to and in from sea, till the two lesser Hoylake lights are brought on a line."

[2] Annals, *Gore's Directory.* Lower Hoylake lighthouse appears as a timber erection in a drawing on a chart as late as 1794.

[3] It bears the date over the entrance, 1763, with the initials W. H. G., being those of William Gregson, then Mayor of Liverpool.

[4] Several of the engravings of public buildings in *Perry and Enfield's Essay* bear the name of P. P. Burdett, del.

[5] *Vide* preface to *Perry and Enfield's Essay.*

[6] The soundings along the northern edge of West Hoyle are evidently taken from Fearon and Eyes's charts.

[7] Annals, *Gore's Directory.*

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[1] Mr. Urmson, the present keeper of Bidston lighthouse, is the descendant of a family long settled in the neighbourhood.—(Vide *Mortimer's History of the Hundred of Wirral.*) He states that he has often heard from his father the story of the burning of Leasowe lighthouse—that the floors were burnt and fell in; so that, looking upward, the interior presented the appearance of a churn, and that the building was afterwards restored. At present, the upper chamber of the lighthouse is vaulted with bricks; and tradition, handed down through the successive light-keepers, affirms that, warned by the former destruction, this vaulted floor was laid with a view to confine to the light-room any similar catastrophe. The traditionary dates are very various and uncertain.

[2] An inquiry into the existence of this lighthouse was published in a small pamphlet, by Joseph Boult, Esq., in October, 1856. His conclusion differs from that given above; but he does not appear to have been aware of Mackenzie's or Hutchinson's allusion to the subject.

[3] I am inclined to think that, if washed away while actually in use, the catastrophe would not have been so completely overlooked in local annals as appears to be the case. If superseded previously, the main part of the structure was perhaps removed, leaving only outbuildings, &c., to be swallowed up by the sea; which, traditionally connected with the lighthouse, were not of sufficient importance to be noticed in the printed annals of the period.

[4] Tradition ascribes the burning of Hoylake lighthouse to the use of a

In the long interval between Burdett's Chart and the year 1813, we have no reliable records of the state of the Estuary; the wants of navigation were met by the issue, from map and chart publishers, of charts copied from former surveys, or collected from such other sources as they could command, paying no regard to changes which on our coast meantime supervened. Sheet 8, by Laurie & Whittle, dated 1794, is an example; the part from the river Dee westward, is a copy from Fearon and Eyes's Survey of 1736-7; and the Mersey Estuary is taken from Mackenzie's Chart. Sheet 9, is another instance, being likewise a copy from Mackenzie; it is a tracing from a plan on a chart by D. Steel, of the Minories, London, published in 1796. I have selected it from among others, on account of a discrepancy between it and the general chart to which it is attached; which consists in representing on the chart two sets of leading marks of three each, leading into Formby Channel; and on the plan, one set. This discrepancy I have exhibited by placing a tracing of the two sets in red ink beside the other. These are illustrations of the incongruities and discrepancies displayed in charts of the period; and even in those of the present day, when published under similar auspices.[1]

Barren as was the period in some respects, we are indebted to it, nevertheless, for some of the most valuable contributions to our hydrographic knowledge of the port. In 1766, Mr. William

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coal fire for illumination, and the discontinuance of the practice to that calamity.

[1] Other charts of this period were—a general chart of the coast, by Capt. John Williamson, published in 1776; new editions of Laurie & Whittle's, down to 1811-12; and similar charts, by Heather, down to the same date; and in 1812, a chart of the bay, by Mr. John Cummins, then harbour-master of the port; also, a chart of the bay, by James Kay, pilot. The last was published by the widow of the author; and on a copy furnished me by the kindness of Captain Washington, Hydrographer of the navy, is a manuscript notation, dated 27th Feb., 1813, to the effect that the entrance from the new buoy through the Horse Channel, and the entrance into Hoylake and Helbre Swash, are very incorrectly laid down, to which is appended the signature of John Cummins above referred to; also, in 1785, was published a reprint of *Great Britain's Coasting Pilot* of Capt. Collins, the charts and sailing directions being identical with those of the edition of 1693. A copy of this edition is in the possession of Mr. Walker, chart-seller, optician, &c., South Castle Street, Liverpool.

Hutchinson, who had held the post of dock-master of Liverpool since 1759, commenced a series of tidal observations, which he continued uninterruptedly till his retirement from his office in 1796. The work was undertaken at the suggestion of James Ferguson, the self-taught astronomer, who furnished a scheme for conducting the register.[1] It contains the height and time of high water every day; the direction of the wind from the true meridian, and its force in miles per hour, estimated "by Smeaton's rule, our great storms going sixty miles;" and the state of the barometer and thermometer. For a considerable portion of the time, there is the estimated rain-fall in eighths of an inch, and notices of the motion of the moon, extracted from an astronomical ephemeris, and daily notations of the weather throughout.[2] The levels were taken by a graduated gauge-rod placed perpendicularly on the Old Dock sill,[3] the time given being called solar time, explained in another work by Mr. Hutchinson as that derived from a sundial.[4] The pains-taking fidelity displayed in this register, persevered in for so many years, can scarcely be over-appreciated; it bore early fruits of usefulness. The observations of the first two years, and those from 1777-80, were presented by the author to Mr. Richard Holden, who constructed from them the first tables predicting time and height of high water that were published in Liverpool. Their value was speedily recognised; and by a law for regulating the pilot service of the port enacted shortly after their first issue, it was made compulsory on every pilot to provide himself with them. In later days, these observations have been subject to lengthy discussion by Sir John Lubbock, who derived from them principles which have led to the formation of tables containing accurate tidal predictions for many other ports.

The barrenness of the period in respect of other records is due, no doubt, to the many disabilities under which commercial enterprise laboured throughout its major part—war, with its pressing necessities, distracting mind and means to other pursuits. In the ten years antecedent to the American War of Independence, Liverpool had advanced with unexampled strides in commercial prosperity; that calamity over, a new era of prosperity seemed to open, and was ushered in with new plans for dock extension. In 1784 an act was passed authorizing the construction of the King's and Queen's Docks; and in 1788 the former was opened for traffic: the latter was not opened till 1796, in which year the French Revolutionary War broke out, and commercial prospects were laid under a shadow. The organization of the inland water traffic enabled Liverpool to prosper in spite of difficulties; and, in 1799, another act of Parliament provided for the construction of docks to the north of George's Dock, and on the site of the present Albert Dock; not, however, proceeded with for several years.

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[1] *Vide* p. 187, in *A Treatise on Naval Architecture, &c., &c., and Seamanship*. By Wm. Hutchinson, Mariner and Dock Master at Liverpool. 4th edition, 1794. A copy in the Lyceum Library, Bold Street.

[2] Original manuscript in Lyceum Library.

[3] *Vide* concluding note to manuscript.

[4] Article *Tides*, p. 187, in Mr. Hutchinson's work, before referred to.

In the years immediately preceding 1813, the condition of the port became subject for grave consideration. In the northern channels great changes had supervened, so that the north-western tower at Formby had to be removed; and, in 1811, a timber landmark was erected on the sandhills, 1000 yards to the northward of the old tower: still much uncertainty prevailed as to this locality, so that the sailing directions of the period discourage the use of the Formby Channel, and despite the disadvantages entailed by its shallow bar, counsel resort to the Rock Channel as the safer. Under these circumstances, the Dock Trustees applied to the Admiralty, who ordered a survey to be made of the port, and the officer deputed for this service was Mr. George Thomas, Master R.N. Hitherto, surveying for nautical purposes had partaken more or less of the primitive signification of the term, nearly in the sense in which a person placed upon an eminence, and thence examining the prospect, might be described as taking a survey of the surrounding country. The earliest treatise on maritime surveying, in a distinct form, is that by Murdoch Mackenzie, published in 1774;[1] in it he explains the application of geometry to the practice; but, at the same time, shews that, from deficiency or instruments, such practice was very limited; and, in detailing the operations for a survey of a harbour, he says—"It is much to be desired that the surveyor should accustom himself to judge distances by the eye, which, by practice, can be done with considerable accuracy, and will thereby save himself much trouble." In an essay on the same subject, published in 1791, the operations afloat are thus directed:—"At low-water, sail about the harbour and take the soundings, observing whether the bottom be rocky, sandy, shelly, &c.: these soundings may be entered in the chart by small numeral figures, by taking at the same time the bearing of two remarkable objects; in this excursion be particular in examining the ground off points of land which project out into the sea * * *, or in the vicinity of small inlands * * *, observe the set and velocity of the tide, by heaving the log when at anchor * * *, and, upon coming near the shore, care must be taken to examine and correct the outline of the chart, by observing the inflections, creeks, &c., more minutely." This was, no doubt, the sum of the method pursued in all former attempts at surveying. The new survey (Sheet 10) ushers into our records a more exact system, which considered as surveyed only such portions as had been actually sounded, measures being taken for constantly fixing, by trigonometrical projection, the position of the vessel engaged in the work, improved instruments enabling it to be plotted roughly while still in progress, thus facilitating the examination of the ground in a systematic manner. But, though mathematical appliances had arrived at comparative perfection, and the system of delineation approached that of our own day, the surveyor had still to contend with difficulties of nature and art, which the enlightened perception of after-times has contributed to counteract or remove. Mr. Thomas's survey, therefore, brings to our apprehension an amount of critical accuracy not previously perceptible; yet, in the absence of facilities, a considerable surface remained unsounded, and, although viewed and delineated according to the antiquated notion of a survey, is described by himself as "not surveyed,"[1] enabling us to distinguish that which he had verified for himself, and that which was derived from local report or other sources. The Dock Trustees had already obtained authority for the stationing of a floating light; and, on the 24th November, 1813, the year of this survey, she was first moored off the port, called, from her compass bearing from the entrance to the Mersey, the N.W. Lightship. She appears on Mr. Thomas's chart, together with several other additions to the buoying and beaconing of the port. Following its completion, the general pacification of Europe gave fresh impulse to the commercial energies of Liverpool. New plans for dock-extension had received the sanction of parliament in 1809-10; and, in 1816, the foundation-stone was laid of the Prince's Dock, which had remained in abeyance since the commencement of the century; and in the same year the Queen's Dock was enlarged. The former was opened for traffic in 1821.

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[1] A copy in British Museum; also, in Lyceum Library, Bold Street, Liverpool. Vide also *Geometrical and Graphical Essays;* by Geo. Adams. London, 1791, p. 362. A short treatise on the subject, by Mackenzie, prefaced his work on the Hebrides or "Orcades," the survey of which he published about 1748.

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[1] Note on Thomas's Chart, 1813.

While these improvements were in progress, at the suggestion of Mr. Whidbey, the engineer of the Plymouth breakwater, a survey of the Mersey was made in 1819-21, from Rock Point to Warrington; it was executed by Mr. Giles, C.E., in such a manner as to admit of close comparison of its results with the future condition of the river. The improvements in progress were those which led to the filling up of the old Dock, the oldest structure of its kind in the kingdom, which was consummated in 1826.[1] In the year following, the oldest beacon of the port, the Rock Perch, gave place to the Rock lighthouse.[2] Meanwhile charts purporting to be from actual survey, made at the request of the Liverpool Dock Trustees, were published by Lieut. Thomas Evans, Royal Navy; the first publication took place in 1814, it was accompanied with a book of directions, and plates explanatory of the process employed in the survey. Among these is the measurement of the base line, which extended from Leasowe Lighthouse to a house in Bootle Bay; the process detailed exemplifies some ingenuity, but fails to explain how the measurement was carried across the water. Lieut. Evans appears to have been practically well acquainted with the locality, from having held the command at different periods of His Majesty's cruisers on this coast, and in the intervals of duty to have devoted his time to the work of his

[1] Baines's *Liverpool*, p. 623. [2] Ibid, p. 625.

charts. However commendable such efforts, they were not sufficiently well directed, to induce results comparable with those of a survey scientifically conducted; they are consequently worthless, except as marking the nature of the efforts made to meet the wants of the period. The latest by this author bears date 1832.

Questions of Dock and River improvement appear for some years almost exclusively to have occupied the authorities; their attention now again was directed to the Estuary. The Northern Channels of Thomas's survey had become almost obliterated by the encroachments of sand-banks, and involved their localities in uncertainty; deep alarm was felt lest those avenues should be altogether lost to the port; again the major part of the traffic reverted to the Rock Channel, the shallowness of which entailed so many inconveniences; when, at the solicitation of the local authorities, Lieut. Denham was ordered by the Admiralty in 1833 to survey the port. The result of this survey was, the buoying of a channel through the north end of the Burbo Flats, called the "New Channel;" the erection of a Beacon, to form with the old Formby sea-mark a leading line through it by day; and the establishment of a second lightship, which, with the Formby Tower converted into a lighthouse, denoted the same line by night, with other considerable additions to the buoying of the port. In 1835, a partial survey (Sheet 11) was instituted, tending to perfect the chart of the former, and leading to further alterations in the buoying.

In the latter year, the Dock Trustees resolved upon the appointment of an officer, to maintain a permanent supervision over the Hydrography of the port, and the appointment was appropriately conferred upon Lieut. Denham, promoted meantime to the rank of a commander in the Royal Navy.

In 1837 another survey testified to the gradual sanding up of the new channel, and led to the adoption of a system of dredging, with the view of forcing another outlet in a direction where the set of the tide and levels of the bottom gave indications favourable to the undertaking; the effect proposed was to deepen a space 1380 yards in length, by 660 yards wide, from a depth varying from seven to twelve, to an uniform depth of twelve feet. The operations commenced late in 1838, continued with intermissions through 1839, and were renewed for a short time in 1840, occupying actually from ten to eleven months of that period. The object sought was considered sufficiently advanced by the autumn of 1839, to warrant the opening of the new channel for traffic, under the appellation of the Victoria Channel. A new lighthouse being erected on the Crosby sand-hills, one and a quarter miles south of the old Formby Tower, and the Formby Lightship shifted to such a position as, with the lighthouse, to form a leading line through it, a beacon being placed on Crosby Point sands, in the same line, as a check upon the position of the lightship. The least depth of water in the channel at the conclusion of the operations, was ten to eleven feet.

In 1840, a third lightship was established at the elbow of the Formby and Crosby Channel, another survey evidencing changes in the northern channels, led to fresh alterations in the buoying, and to the addition of two new beacons to the northward of Formby Point, to mark the Fairway into Formby old channel—also to the erection on Grange Hill, on the shores of the Dee, of the Grange Beacon, as a substitute for a mill, which had long been useful as a sea-mark.

The survey of 1846 resulted in the removal of the Crosby lighthouse half a mile to the northward of its first position, to meet the changes in Victoria Channel. In 1852, a continuance of change necessitated the abandonment of the lighthouse on Crosby shore, and the re-appropriation of the old S. E. Tower at Formby for that use. And this arrangement was reversed at the conclusion of the survey of 1857 (Sheet 12).

Contemporaneously with the progress of these and intermediate partial surveys, new appliances and facilities were constantly brought to the work, contributing to an advance in the accuracy of the results derived, and surveys of neighbouring coasts added materials enlightening our views of the port. Of prominent importance were the tidal observations of Captain Beechey, who, for several years previously to 1848, was employed in the deep water of the Irish Channels and neighbouring seas, specially to collect such information. The results of his labours compiled by himself, with those of the surveyors employed at the same time on the adjacent coasts, afford the best data existing, whereby to estimate the forces which control the currents of ebb and flow in our Estuary.[1] Captain Denham attempted, from his own observations in the Mersey, to lay down some definite conclusions[2] as to tidal action, which have not, however, been sustained by subsequent observers—of the new appliances, those of principal importance are the self-registering tide-gauges, established in 1854 on George's Pier Head and Helbre Island.

Throughout the period included in those modern surveys, Dock-extension, from being a question admitting of long intervals, had become a matter of daily progress, and to those already completed were added, the Albert, the Coburg and Union Docks, the Brunswick and Toxteth Docks, and the Clarence, Waterloo, Victoria, Trafalgar, Salisbury, Huskisson, and the Sandon Docks. While on the Cheshire shore private enterprise commenced a system of Docks, closing the entrance to Wallasey Pool, which, yet incompleted, have lately passed to the Liverpool Dock Estate.

The records we have passed in review, open with the small general chart by Captain Collins in 1687, exhibiting the sea, bordered with the sandy fringe before alluded to; in the chart (Sheet 1) of a century and a half later, the same grand natural features of the coast are impressed upon our attention; making due allowance for difference in the manner of execution of the two works, the changes witnessed will be found to belong to local areas, and scarcely affect the general aspect. The near approximation of these features at the commencement and near the termination of our records, indicate that the origin of the condition they represent, must be arrived at through causes operating from a remote period of time. The early acts of parliament, relating to the Liverpool Docks and Harbour, refer to the sands of the Bay in terms similar to those now applied to them, certainly not regarding them then as any new feature;[1] similarly their mention in our early hydrographic records, and the description of their changes there point to no recent origin, but are applicable in a general sense to the present period; descriptive accounts of the shores belonging to ages prior to our hydrographic records,[2] and casual references to the neighbourhood in still earlier times, imply the maintenance of a condition similar to that now existing. Further attempts to seek its origin must proceed upon scientific conjecture, and, although to be received only as such, with the hope of throwing some light upon future considerations, I propose to dwell briefly upon its probable ancient history.

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[1] *Phil. Trans.*, 1848; "Report on Irish Channel Tides." By Capt. Beechey, R.N. Also, *Annual Admiralty Tide Tables.*

[2] Respecting the half-tide level—*Transactions of British Association*, 1835 and 1837. There is now no difficulty in showing, that the half-tide level is not constant at several places on the neighbouring coast, as at Liverpool and Helbre; and also, that at the same place it varies constantly and considerably from the mean level.

A singularity is presented to us in the component particles of the sandbanks of the Bay, and their wide-spread distribution, relatively to the coast formations to which they adjoin; their material seems to ally them to the friable strata of the neighbouring new red sandstone formations, the extent of which is apparent in the coloured portion of the map No. 13., being an extract from Sir R. Murchison's geological map of England. It will be seen to embrace the coast, from Abergele Bay in Wales to Lancaster, and from Ulverstone to near St. Bee's Head, the immediate coast line from Formby northward, having superimposed post-tertiary and recent deposits. The coast of Morecambe Bay, wherein we find the largest accumulation of sand, belongs to a considerable extent to the older and harder formations, incapable from their nature of contributing, except in a minor degree, to the accumulation; and the streams flowing through the sandstone strata, are obviously insufficient of themselves to account for its wide-spread distribution.[1] If from the northern extreme of the sandstone near Lancaster, we draw a straight line to its western extreme in Abergele Bay, we enclose a large area of sea, wherein we may reasonably conclude that the substratum will be a continuation of that of the adjoining coast, with a similar continuation where the same formation borders the coast between Ulverstone and St. Bee's Head; the whole a series of sedimentary strata, accumulated through many ages in the depths of a sea existent in a distant geologic epoch. Geologists concur in representing the northern parts of Europe, with large portions of our isles, as rising towards the close of the tertiary period above the level of the sea,[2] we may picture to ourselves the aspect of this portion as it emerged into dry land; the different strata more or less consolidated into rock, as they approached the surface of the waters, again becoming subject to abrasion and re-deposit, the shallow sea margins collecting a surface of sea-drift and merging into marshland, the land drainage piercing the friable strata, and wending its way toward the ocean, which at length[3] subsiding within its present limits, found its bounds determined, by the collected sediment and detritus of former ages: the abrasion of submerged strata, and the erosion of land by drainage, have continued to operate in slowly adding to the ancient accumulation which has been moulded by the forces acting upon the new sea, until assuming the form now witnessed.

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[1] Eighth Queen Anne, cap. 12, states, "That the entries into the port have been found so dangerous and difficult, that great numbers of strangers and others have frequently lost their lives, as well as ships and goods, for want of proper landmarks, buoys," &c. —Baines's *Liverpool*, p. 347.

[2] "From Warrington, the Mersey, spreading and presently contracting, its stream falls into the ocean, with a wide channel convenient for trade, where it opens to view Litherpool, commonly called Lirpool, from a water extending like a pool."—Cambden's *Britain*, vol. vii., p. 137, Troughton's *Liverpool*. "The bar that is called Chester Bar, that is, at the very mouth of the sands spued out of the Dee river, is an eight or ten mile W.S.W. from Hilbery island. It is, by estimation, a sixteen mile to cross strait over to the next shore of Lancastershire; for Lyrpole lyeth a ten miles into the land from the mouth of the Mersey water, and little lack of twenty (miles) from the very bar of the Mersey, that lieth in the main sea." —P. 55, vol. v., *Itinerary* of John Leland, 1530-40; Hearne's 3rd edition, Oxford, 1769.

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[1] The Mersey, with its tributaries, the Tame, Bollin, and Weaver; the Dee, and Clwyd in Wales.

[2] Somerville's *Physical Geography*, vol. i., p. 34. "Hence excessive cold prevailed during the latter part of the Pleiocene period; and a great part of the European continent was covered by an ocean of floating ice, not unlike that seen at this day off the north-eastern coast of America. During the latter part of the Pleiocene period, however, the bed of that glacial ocean rose partially, and, after many vicissitudes, the European continent assumed nearly the form it now bears."

[3] "All the changes before, during, and after the glacial epoch, appear to have been gradual, and not sudden, so that no marked line of demarcation can be drawn."—Paragraph No. 11 of the conclusions taken from *A Survey Memoir on the Connection between the Distribution of the Fauna and Flora of the British Islands*, p. 65; by Professor Edward Forbes. "Time, which man measures by days and years, nature measures by thousands of centuries."—Somerville's *Physical Geography*, vol. i., p. 38. It is important that, in considering the origin of the sands, we should give full force to the points thus indicated; viz., their gradual accumulation during a space of time scarcely comprehensible by our mode of measurement.

Turning from the general features to those which appertain to the Mersey Estuary, we are impressed with the small proportion the latter bear to the whole accumulation, and how infinitely small a proportion is that which is affected in the course of a few years by the disturbance of the sea channels. The characteristics of our records, and the changes they chronicle, suggest their classification in the following periods; the first, opening with Captain Collins's survey of 1687, running over a barren period of forty-eight years, down to 1736; the second, comprising nearly a century, furnished with several points of illustration, commencing with Fearon and Eyes's survey of 1736-7, concluding with Captain Denham's of 1833-5; and thirdly, the subsequent modern period, down to the latest survey, 1857. To assist our illustration of these periods, I have selected portions of several charts for special treatment, enlarging them to the scale of the latest survey;[1] and, to facilitate the comparison of the same localities in each, have squared them on the magnetic meridian of 1857, colouring those portions representing sandbanks in the originals with a sandwash, the higher portions being brought out with a darker shade, the land distinguished by a neutral tint, and the paper left blank for the water.

It will be observed that Captain Collins's chart (Sheet 2), includes but a small section of Liverpool Bay, and is not in fact, nor from its title had it any pretension to be, a chart of the Mersey Estuary. In it we recognise Hoylake, the Horse and Rock Channels, Hoyle Bank in an unbroken mass covering the entrance of the Dee, and the Burbo, then called Formby Banks, stretching northward from the Rock land; the soundings, thinly scattered, give scarcely any data as to depths of water, and the banks are so described as to give but a faint idea of their relative levels. The Horse Channel indicates a roomy passage with five and six fathoms depth, Hoylake with an average breadth approaching three quarters of a mile, and a prevailing depth of from five to seven fathoms; we may conclude that the highest part of Hoyle Bank was situated somewhere within the limits denoted by the darker sháde, and that it attained a level of from twenty-two to twenty-four feet above low water. The condition of the Rock Channel is still more vaguely defined; the portion described as "all dry at low water" is not graphically represented as sandbanks, while (perhaps from an error of the engraver)[1] the notation extends beyond the dotted line, apparently intended to define the limits to which it ought to apply. This is no doubt the part alluded to in the sailing directions as the "flats" to pass over which ships bound for Liverpool had to wait in Hoylake for water. It seems probable that Captain Collins himself thus waited for water to enter the Mersey, and consequently did not examine the Rock Channel at low water; but, finding his soundings nearly in accordance with the fact, he inserted the warning notation, derived in the first instances from local report.[2] The Formby Channel is not included in this chart; but we may venture to believe that it was sailed through, and the depth stated at three fathoms verified, as on the small general chart we do find such a channel described; but from its being "unknown" for want of buoying and beaconing, it did not come within the author's purpose to enter into particulars respecting it.[3] If we inquire as to the actual area of the banks dry at low-water, we are involved in a difficulty arising from the superficial nature of the work, and from our inability to comprehend the old system of graphic delineation, or more correctly, perhaps, from absence of system.

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[1] Viz., the Surveys of 1687, 1736-7, 1767, 1813, 1833-5.

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[1] That such errors are more than probable, is shown by the following extract, p. 12, of *Great Britain's Coasting Pilot*:—"The draught of the Severn is not so well finished as intended, by reason the engraver lost the original copy."

[2] A notation in the Rock Channel: "Ste epwarp," the interval occupied by the sign denoting anchorage, is at first sight enigmatical. I believe it signifies *steep wharf*, and is a description intended to apply to the banks bordering the entrance to the shoal water in the gut.

[3] If Captain C. had not verified it, he would probably have treated of it as he does of the Owers rocks on the coast of Sussex; where, after giving clearing marks, he adds, that there are channels inshore known to local pilots; but, as his province is to show how dangers may be avoided, he forbears further mention of them.

For instance, sandbanks dry at low-water are now understood as represented by a dotted surface, (though as we shall see hereafter the rule is even yet not uniform;) but this obviously was not the intention of the author in the present case, as is seen by the dotted knoll westward of Chester Bar, marked with a depth of three fathoms, and, the depths of one and two fathoms on the Pile off Walney island, in the small general chart. The difficulty will be solved, I think, if, remembering the expressed purpose of the author only to warn against danger, we believe that such portions were intended to define, not simply dry sands, but also the limit of known danger, *i. e.*, water not navigable. This idea would account for the unnaturally symmetrical form of the banks; for it would accord with his purpose, lest mariners should be tempted to avail themselves of apparent inlets, to warn them against such, by depicting them as barred by the line of danger. The rise and fall of tide, given at Liverpool as thirty feet in spring tides, and twenty-two feet in neaps, and a statement that the tides run stronger before Liverpool and are weaker in the Sloyne, comprise all the information we can gather as to the tidal phenomena.

The variation of the compass was ascertained at Edinburgh in 1685, 6° W., Aberdeen and Cromartie, 6°30 W., Orkney and Shetland, 7° W., and Greenwich in 1693, 6°30 W.; "the same," says Captain Collins, "throughout England, to a small matter."

The subsequent history of this period is indicated only by some casual allusions in the work of Messrs. Fearon and Eyes of 1737. A channel between Ferny Wharf and the south point of Hoyle Bank is described by them as the "old channel," at that time almost closed up; and we are told that "by some accounts it appears that Hoyle Bank is come nearer to the main, and Hoyle Lake is not so broad as formerly, which probably is occasioned by a swash which enters opposite to Helbre, and runs near in a straight course out to sea. In this swash runs a strong tide, both flood and ebb, in and out of Chester water, which formerly run through Hoyle Lake, where the tides are not now so strong as in times past. What changes this swash may produce in Hoyle Lake we shall not undertake to determine; but it seems to us worthy the thoughts of better judges, in order to consult proper methods and helps for conducting vessels safe into this road, or any thing that may tend to the preservation of the same." And of some flats lying westward of Wallasey Hole, occupying a position indicated as sandbank by Captain Collins, it is said, "here was deeper water formerly than is here at present," thus implying a double change, a former deepening and present filling up. And again, near the Rock Perch, "this was formerly divided into two parts by a bank, called East Burbo, but now so low as is little regarded." The difference in the manner of executing the survey which illustrates the commencement and conclusion of this era, prevents a close comparison of the localities they describe. In the latter the contraction of Hoylake is made apparent, as well as its decrease in depth to from three to five, instead of five to seven fathoms, as in the former chart. The depths in the Horse Channel are stated in the work, and shewn on the chart at seven and eight fathoms, *i. e.*, deeper than before. Nevertheless, they do not establish the fact of an increase in depth, because, from the few soundings exhibited on the first chart, there is no evidence that such depths as were afterwards found did not then exist. Captain Collins's description of Rock Channel has been noticed, and we have considered how his information was probably derived: although differently delineated in their chart, Messrs. Fearon and Eyes describe it in nearly the same words, viz., "mostly dry at low-water;" to which they add, "except a narrow gut, with only four feet at low-water," an exception which, in Captain Collins's superficial method of treating the subject, would not have been of sufficient importance to receive notice. The two descriptions imply probably, as respects the general level of the locality to which they refer, a condition almost identical. In Hoyle Bank we find a change by the breaking through of Helbre Swash; the highest part remains in level as nearly as possible the same as before, although it has changed its position nearer the shore.

The illustrative points occurring in the second period of a century, from 1736-7 to 1833-5, stand so isolated as to represent of themselves little more than bare facts. In the succeeding modern period, successive stages in the transitions of the banks and channels have been noted in such a way, as, together with the record of some physical phenomena, to give views of intervening situations, which reflect their light upon the isolated positions of the former period; therefore, after tracing the points which mark the commencement and conclusion of these two periods, we will endeavour to contrast their intervening aspects with each other.

In each period we have two principal channels into the Mersey suitable for the purposes of navigation; viz., a southern channel, parting at right angles from the main stream of the Mersey, close to the northward of the Rock land, and pursuing a course to its confluence with the Horse Channel, nearly parallel to the Cheshire shore, being in all cases nearly dry at low-water. To the northward, a wide channel, separating the Formby and Burbo banks, shoalest at its seaward end, having there a depth at low-water of from ten to twelve feet; again, to the northward of this a third channel, very shoal at low-water, and taking a more northerly direction, used mostly by coasting vessels. Helbre Swash appears in each, and Hoylake in all records except the latest survey. These general expressions represent points of assimilation, perceptible in both periods; differences will be best appreciated by inspecting the chart of 1833-5 (Sheet 11), on which is traced a light under-tint, displaying the situation of banks and channels taken from Fearon and Eyes's chart of 1736-7.[1] The principal difference is the great decrease in Hoyle Bank; the remainder consist of an interchange of position between various banks and channels. Hoyle Bank continues throughout at its highest part at nearly the same level.

The levels of Burbo, from its being cut up into many patches, are less defined; its highest part, however, seems to have remained constantly near the borders of the Rock Channel, and here there is an apparent increase of height in the later records. In addition to features common to the commencement and conclusion of both periods, we have at the termination of our latest period, in 1857, a channel just to the southward of the principal northern channel which we can trace by means of intermediate surveys through all its antecedent history, and here we lose sight of Hoylake, the level of the bottom having there risen to from seven to seventeen feet above low-water level.

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[1] It may here be remarked, that the general correctness of this chart and subsequent ones by John Eyes, is testified by the accuracy with which objects, common to that and charts of the modern period, coincide in their relative situations on the enlarged scale.

It will be remarked that these facts, with their contrasts and comparisons, touch but lightly upon the question of comparative areas and levels; and refer to the several localities in terms appropriate to the purposes of navigation, such being the chief object before the minds of the authors, and the purposes to which their labours were designed to apply. The original purpose having been fulfilled in all except the latest chart, the specific relations of areas and levels they develope, are the points which, in seeking instruction as to the future, most interest us. In diverting the works of our authors to this question, we are met almost at the outset by the difficulty arising from their intent, to describe dangerous navigation, where we propose now to inquire the area and level of sands above water; we have seen how such inquiry, with reference to our first period, is frustrated. In the definitions attached to their chart, Messrs. Fearon and Eyes describe the dotted portions as "dry sand," but we do find depths of water marked upon them in Westbury Swash and in some swashes through Burbo. Again, Hoylake is described as half a mile wide, and Dove Point one and a quarter mile from high water, neither of which agree with measurements on the chart, and can only be reconciled by believing that in some parts the dotted portion is extended beyond the dry sand, representing a margin of danger. This margin would certainly include only very shallow water, because the authors have introduced, in their survey of 1736-7, a system of noting depths in feet, distinguished by being included in dotted lines, and this system is applied where the shallow water is of any considerable extent. To this cause of uncertainty as to the limit of dry sand, in the charts representing intervening situations in the centennial period, we must add that of their being only partial surveys; coming to our own age, the same uncertainty to some extent still exists, as we are accustomed to describe spots where the water is of less than two feet depth as a-wash, and to delineate it as dry sand. Causes of uncertainty have diminished with the increase of general accuracy, and will continue in after times to decrease, probably placing future inquirers in the same difficulty with our own charts as we find in those of our predecessors. The survey of Fearon and Eyes's approaches in style of execution more nearly to works of our own day than any other of those we have considered (except Thomas's, which is thrown into shade in the question now under consideration by reason of large tracts remaining unsurveyed); but the uncertainty spoken of being of a nature which more or less pervades all, even our latest records, we may venture to compare the areas they severally represent, taking the results simply as an approximation to truth.[1] Then denominating, for argument's sake, all dotted surfaces as dry sand, and dividing the features under headings suggested by their location, we have as follows:—

AREA OF SAND-BANKS DRY AT LOW-WATER.

1st. In the space lying eastward of Helbre Swash, and southward of a line projected to the north-westward from Formby Point.

BANKS OUTLYING OR DETACHED FROM THE SHORE.

In 1735-6.	Sq. Miles.	1833-5.	Sq. Miles.	1857.	Sq. Miles.
Burbo	10·35	Burbo	8·66	Burbo	8.40
Mock-beggar, or Beggar's Patch	·80	Little Burbo, Jordan's, & Taylor's	·84	Jordan's and Taylor's Banks	2·30
Mad Wharf . . .	1·97	East Hoyle	4·92	East Hoyle . . .	5·74
East Hoyle. . . .	3·42				
Total outlying banks	16·54		14·42		16·44

BANKS ATTACHED TO THE MAINLAND.

	In 1735-6. Sq. Miles.	1833-5. Sq. Miles.	1857. Sq. Miles.
Rock to Redstones	2·93	3·42	2·88
Formby shore to Bootle shore .	8·50	9·98	7·74
	11·43	13·40	10·62
Detached Sands brought down	16·54	14·42	16·44
Total area subject to uncover and cover by the tide	27·97	27·82	27·06

Turning our view westward, we have data only for the commencement and conclusion of the centennial period; and, bringing forward the results already obtained, we find as follows:—

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[1] A further uncertainty arises, from our not being acquainted with the data whence the early surveyors derived their low water level. Then, as now, charts purported to show the depth of water at "low water of ordinary spring tides"—a definition which has met with very various interpretations. The latest survey of Liverpool, purporting to show the depths reduced to the same level, really exhibits them reduced to a level of 10 feet below O.D.S., or about 1¼ foot below the mean spring low water level. I inclined at one time to the idea, that this discrepancy arose from the survey of 1833 having been made during the spring or autumn of the year,

Westward of Helbre Swash, and Northward of Point of Air.

	1735-6.	1833-5.
Detached—West Hoyle	19·70	11·64
Attached to Welsh coast	3·64	2·60
	23·34	14·24
Brought forward	27·97	27·82
Total square miles of sand dry at low-water	51·31	42·06

Beyond what has been already said on the subject, the comparison of levels from the charts would be fruitless because, where we find a notation, "dry" at a certain time of tide, we have no means of ascertaining the area to which such notation applies. According to modern practice such does apply often to only a small spot which, happening to rise high above the levels around it, obtains for the bank the warning notation, although the surrounding portion of it may at the time described be still several feet under water, the object being to warn against an approach to those spots being made at improper times of tide. But another method will serve not only to test the results above given as to area, but also to afford evidence on the question of level: it is clear that a great increase in either respect, but more especially

when a mean of the tides would have given a lower level than if taken for a whole year; but in the tables for ascertaining the depth of water at certain times of tide, appended to the charts, two feet is given, to be added to the depth shown on the chart, to find the low water level at spring tides. The adoption of the lower level arose, probably, from a desire to be on the safe side, and to warn mariners by showing too little water, rather than make them over confident by the possibility of showing too much. And the same level is still retained; because an addition of one foot to the depth of water would throw a considerable portion of the sands under water, and so alter the appearance of the chart as to render comparison with former surveys complex. The level shown is really that attained at equinoctial tides. With this discrepancy in view, and seeing that a change of one foot in the level of our data would make so much difference in our modern charts, it must be remembered that, from the various interpretations that have been put upon the definition, we do not know to a foot what was the "low water of ordinary springs," quoted by our early surveyors; therefore, our comparisons must be taken as instituted under only a proximate similarity of condition.

in the latter, must impede the flow of water into and out of the river, and result in an alteration of the water-level at any given spot subject to its influence. With this view, I have compared the high water levels taken from the three first years of Mr. Hutchinson's observations at the Old Dock Sill with three years' observations taken by our self-registering tide-gauge at George's Pierhead; the intervening period giving a lapse of eighty-six years, which is, perhaps, as a drop of water in the ocean of time, during which the entire formation has accumulated,*but which, including the operation of extensive artificial changes in the river, is interesting, and should be sufficient to indicate any effect they may have developed in combination with pre-existing natural causes upon the banks in the bay. The following figures are derived from the sources named:—

1st, Mean Height of High-Water Throughout the Year.

	No. of Tides Observed.		No. of Tides Observed.
1768—15·510 feet above O.D S.	703	1854—15·424 feet above O.D.S.	663
1769—15·362 „ „	705	1855...15·425 „ „	678
1770—15·505 „ „	705	1856—15·515 „ „	651
Mean of 3 Years 15·459 „ „		15·454 „ „	

2nd, Mean Level of Highest Spring Tides Throughout the Year.

1768—18·590 feet above O.D.S.	1854—19.030 feet above O.D.S.
1769—18·673 „ „	1855—18·783 „ „
1770—18·816 „ „	1856—19·236 „ „
Mean of 3 Years 18·693 „ „	19·016 „ „

Hutchinson's observations give no levels but those of high water; we are therefore unable to enter into a comparison of the mean and low-water levels.[1] But the first of the above tables, shewing a mean derived from nearly all the tides in each year, is highly important, and most remarkable from the accordance it presents at two distant periods. The results of the second table are in a slight degree less harmonious, arising from the small number of observations from which the mean is drawn, being the highest tide in each spring tide, and from contingent causes which, affecting one or two such observations, raises the mean of the whole; thus, the high mean of 1856 is due to the extraordinary rise of one tide to a level of 22 feet 11 inches above O.D.S.

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[1] Mr. Hutchinson observed several tides at low water, by fixing a staff on the shore beyond the entrance to the dock; and although, from the inconvenience of observing under such circumstances, he did not himself put much confidence in the results, he states that, from those, and from observing the rise of a tide when the low water coincided with O. D. S., his conclusion is, that the 4½ foot mark above O. D. S. is about the half-tide line, although it does not agree with the half time of flowing or ebbing. That half tide level agrees nearly with that recently ascertained from three years' observation, which is 4·9 feet above O. D. S.; the unsymmetrical form of the tidal curve implied in Mr. H.'s remark, has been proved by all recent observations.

The conclusions flowing from this comparison of tidal levels coincide with those deduced from the measurement of areas, and go to establish the fact which, at first sight, seems at variance with everyday experience; viz., that the sands of the bay in two respects, area and elevation, present evidence of only trifling change—so trifling that, from the data we have given, it would be difficult to pronounce whether they were on the increase or decrease. Natural causes seem to operate for the former, which may, I believe, be taken to be the fact; and any apparent decrease arising from our figures ought to be ascribed to the increased accuracy attained in delineating the inflections in the margins of the banks, whereby spaces which formerly would have been included in the banks are now recognised as water. We have here confined ourselves strictly to the Mersey Estuary; looking westward, very different results are presented. The decrease in West Hoyle is so great as to be beyond question. The contrast is interesting to us, although its causes lie in a region somewhat beyond our present contemplation. The year of the publication of Fearon and Eyes's survey coincides with the passing of the act which authorized the turning of the upper part of the Dee into a new artificial canal, and gave powers to a company whose profits were mainly dependent upon the land they should by those means be enabled to reclaim from the river Dee; the result has been the damming out of tidal water from several thousand acres, not of marsh land occasionally overflowed, but from spaces formerly overflowed by almost every tide. The conformation of the Dee is the anti-type of the Mersey, and it is well known that, from the date of the earliest settlements on its shores, a constant struggle has been maintained between art and nature, in what has proved a futile attempt to retain navigable water in the upper parts of the river. There is no question but that the operations of nature, so long vainly contended against, and often actually assisted by the mistaken means used to oppose them, have added largely to the accumulation of sand in the Dee; and this increase, derived from the outlying sands, must be looked to as having mainly contributed to the diminution of the Hoyle Bank: portions of its sands may, indeed, have been distributed in the outer parts of the bay, but the data of the earlier surveys referring to those parts are not sufficiently defined to enable us to detect the fact. Thus, the portions of the bay bordering the outlet of the two rivers are, like the rivers themselves, anti-types of each other.

The maintenance of the same general level and area of sands, dry at low water, in the Mersey Estuary, does not necessarily imply uniformity of condition in other respects. In the modern period, we have the partial history of three channels successively appearing between the Formby and Burbo Banks. The first, called the "New Channel," discovered in 1833, continued navigable for six years after; and within eight years from its discovery became obliterated. The second, the "Victoria Channel," first opening in 1838, buoyed and arranged for navigable purposes in 1839; and in 1857, after gradual deterioration, disused, and superseded by a new channel, the Queen's, recently opened near the same locality. For comparing these channels with those of earlier date, it will be convenient to consider their features separately: first, in their relationship to the main channel of the Mersey, exemplified in the angle of their divergence from its course; and afterward, the order of their successive appearance.

The New Channel, when discovered, had a north-westerly aspect, and gradually altered its line of bearing till it closed up, having attained a westerly aspect; the Victoria Channel opened in the same way, with a north-westerly aspect, and has since followed the course of its predecessor, in gradually turning to the westward;[1] and the Queen's Channel has opened with an aspect something more northerly than either of the other two. The diagram (Sheet No. 14) illustrates the nature of this change of direction. It exhibits the fairway lines of the several channels named, and of others, at the dates specified against each; with the angle formed by their incidence upon the fairway line of the main channel from the Mersey, at the same dates; the whole being arranged on the same scale as the charts, so as to show the relative situation of each channel with regard to the others. The following is a statement, taken from the diagram, of the angles included between the fairway lines of the main channel and its seaward branch. In the

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[1] I shall, perhaps, be here reminded that the Victoria Channel was formed by artificial means, viz., by the dredging operations instituted by Captain Denham. The effect of those operations was, I believe, greatly overrated at the time, an opinion which was latterly entertained by the

NEW CHANNEL.		VICTORIA CHANNEL.		QUEEN'S CHANNEL.	
Year.	Degrees.	Year.	Degrees.	Year.	Degrees.
—	—	1838	—	1854	162
—	—	1839	150	1856	159
—	—	1840	150	1857	159
—	—	1846	150	—	—
—	—	1849	146	—	—
1833	133	1851	134	—	—
1835	133	1852	126	—	—
1837	125	1854	124	—	—
1839	112	1857	113	—	—
1841	(Obliterated.)	(Not yet closed.)		—	—

late Marine Surveyor, who took part in those operations. But, in the opening of the Queen's Channel, we have a direct means of testing and comparing them with the unaided operations of nature. The proposal with respect to the Victoria Channel was, that a space of 1300 yards by 660 yards, having a depth varying from seven to twelve feet, should be deepened uniformly to twelve feet. In 1856, the Queen's Channel bar presented a space of 1200 yards by 600 yards, with a depth varying from eight to twelve feet. The results of two years, in which nature was assisted by dredging in the former, and one year left to nature unassisted in the latter, are as follows:—

	Area, yds.	Date.	Least depth.	Date.	Interval.	Area reduced to	Depth increased.
Victoria Channel......	1300 × 660	1837	7 feet	1839	2 yrs.	660 × 650 yds.	11 to 12 ft.
Queen's Channel.......	1200 × 600	1856	8 feet	1857	1 yr.	600 × 600 yds.	10 to 12 ft.

Here is given the operator's own statement of the amount of success which attended his labours, which naturally put the most favourable construction upon them. It amounts to this—that, in the first instance, the area of the bar was reduced one-half, and the depth increased four feet in two years;

The progressive increase of divergence from the main stream will be readily observed, in the decrease of the angle contained between the fairway lines at their point of incidence. The identity of relative direction implied in the earlier phase of the Victoria Channel, must not be taken to signify any cessation of change in other respects; the fact being, that changes in its adjoining banks were in just as active progress then as at any other time, but were effected in such a manner as to preserve the parallelism of the fairway lines, while both the main channel and its branch were undergoing simultaneously a transfer of their location. The subsequent diminution of the angle was accomplished by the growth northward of the elbow of Burbo, towards the apex of the angle of incidence; and the extension southward of the bank bordering the seaward end of the branch channel on its northern side. The history of the Victoria Channel (yet incomplete) is the nearest approach to the complete history of a channel that our records afford. In its predecessor, the New Channel, the same action as above described is traced, resulting in effects which produced complete obliteration; the angle of incidence, stationary for two years, diminished more rapidly than in the former case. The Victoria Channel, from its opening to the present time, has endured about nineteen years; whether it will become entirely obliterated, like its predecessor, or degenerate to one of those narrow gullies, barred by shoals, with deep holes between (several examples of which are in existence), it would be hazardous to conjecture; but, from the rate of its deterioration, it may be supposed that, for two or three years to come, it will still be useful for purposes of navigation; thus making its entire duration something over twenty-one years. Of this period, it will be observed, that during nearly the first half the change in the angle of incidence was suspended; the first two years recorded of the New

and in the latter, the area of the bar was reduced one-half, and the depth increased two feet in one year. The measures pursued in the course of the operations—that of dragging a harrow over the space to be deepened during part of the ebb tide, trusting to the force of the stream to transport beyond the bar the surface disturbed—seem disproportioned to the undertaking; and, after the above comparison, there appears no reason for distinguishing the Victoria Channel from others formed by natural forces only.

Channel show a similar suspension of change to have occurred there. Taking, therefore, the latter year of this suspension as about the central period of duration in each case, would give only fifteen or sixteen years as the entire period of the latter; placing its commencement about the years 1826—8. We have only the opening phase of the Queen's Channel; which, however, seems to witness to suspension of change in the angle derived from its divergence from the main stream.

Respecting the same phenomena in other channels, we have the following:—

New Channel of John Eyes.		Formby Channel.		Old Formby Channel.	
Year.	Degrees.	Year.	Degrees.	Year.	Degrees.
1755	110	1736	116	1813	158
—	—	1755	116	1833	152
—	—	1767	106	1857	135
1767	87	1813	77	(Closed.)	

The South Channel of 1813, presenting no other data for comparison with itself, is omitted for the present. In those above, we perceive the same progressive increase in divergence of the branch from the course of the main stream, that we have before dwelt upon. Taking the channels in their relative order, from south to north, we have first, the most southerly, the New Channel of 1755, with its angle at the point of incidence from 110 to 87 degrees; next, the New Channel of 1833, its angle decreasing from 133 to 112 degrees; then the Victoria, from 150 to 113 degrees (not yet closed); then the Queen's, recently opened, at 162 to 159 degrees. The Formby Channels, named above to exemplify the progressive increase of divergence, I reserve for especial mention hereafter. In this enumeration it will be perceived that the apex formed by the incidence of the fairway lines has been more or less acute relatively to the location of the channels—the more southerly the more acute, and conversely for the more northerly. Observing the increase of divergence toward the close of each channel, it would appear probable, at first sight, that the amount of divergence from the main stream with which any branch originated, would affect the period of its duration;

that the more nearly, at its commencement, the branch coincided with the course of the main stream, the longer it would be in attaining that degree of divergence which would bring about its close; a probability which seems affirmed by the relative duration of the New Channel of 1833, and its successor, the Victoria Channel. The period of the first was arrived at by assuming that, like its successor, the suspension of change in the angle of incidence terminated with the middle of its duration. Of the former New Channel we have only two dates; at the last it was so entirely closed by the growth of Taylor's Bank, that its close for purposes of navigation must be taken to have been consummated some years before; and, observing the acuteness of its angle of incidence compared with that of its later namesake, it seems probable that its entire duration was something shorter; its commencement having been probably about 1747-50. Looking, then, to the Queen's Channel, and considering its more northerly location, and its angle of divergence from the main stream at its opening, similar reasoning would pronounce its probable duration as proportionably longer than that of its next to the southward, the Victoria; implying, with respect to the region under consideration, that the more southerly the situation of the branch channels, the shorter will be their duration, and the converse.

The order of the successive appearance and disappearance of such channels, we trace in the modern period in three cases: the most southerly, the New Channel, having been superseded by its successor opening in its immediate neighbourhood, and to the northward of it; and the Victoria Channel, similarly superseded by the Queen's Channel opening to the northward of it. This northward progression, associated with the decrease in the angle of divergence, which we have seen to accompany the more northerly situation, attended also by the increase of duration, strongly suggests the idea of succession by some regular law of rotation. The lapses of time subsisting among the records of the former period, prevent our following such rotation throughout; nevertheless, I venture to trace an outline, and, for comparison sake, place it beside that of the modern period :—

MODERN SERIES, COMMENCING ABOUT 1826-8.

Name of Channel.	Duration.	Date of Termination.
New Channel, 1833	15 to 16 Years	1840
Victoria	21 to 25	1859–64 (Probable.)
Queen's	—	Unknown (Probably 24 to 28 years.)

FORMER SERIES, COMMENCING ABOUT 1747-50.

Name of Channel.	Probable Duration.	Date of Termination.
New Channel, 1755	14 or 15 Years	1761–2
Unknown	21 or 25	1780–5
Unknown	24 or 28	1804–8
South Channel, 1813	25 or 29	1833

The comparison shows our paucity of information on the subject in either period. In the former period I have assigned to the New Channel a duration of about fifteen years; Mackenzie's chart, wherein the buoys and directions are said to belong to the year 1771, shows a channel which, in its situation relatively to the New Channel, accords with the effect due to northward progression, and which would answer to the first "unknown," followed by another, of which we have no record: the concluding member of the series we trace to its close in the Halftide Swatchway of 1833. I have entered against each durations deduced from our modern series, not that I assume each series will always be uniform either in number or duration.

The Queen's Channel lies not only to the northward, but its seaward entrance is also considerably to the eastward of that of its predecessor. A succession of changes in the same direction must locate a channel hereafter near the position of the Formby Channel of 1736-7, or the South Channel of 1813, both of which seem to mark the conclusion of a series terminating a rotation renewed by those on which we have dwelt. We proceed, therefore, to remark the circumstances attending the termination and renewal of such series. In relation to the opening of the New Channel of 1755, when first surveyed it is remarked by John Eyes:—"The tide which formerly ran through Formby Channel being decreased in proportion to the quantity of water carried through this New Channel, has occasioned shoal water between the Middle Patch and Burbo; where formerly was five and six fathoms at low water, there is scarce twelve feet at present. It is probable that Formby Channel may suffer much greater alterations * * *, by the diverting so great a quantity of water, which formerly was the scour and chief means of keeping it open." The effect described is shown on the chart of 1755, where the seaward branch of Formby Channel remains but little altered, and a silting up of the main channel, just within the angle of incidence of the fairway lines, has taken place. A similar operation is evidenced in the survey of 1833, where the locality of the elbow of the South Channel of 1813, is seen occupied by the shoal water and dry patches of the Halftide Swatchway. In the above quotation the cause seems to have been mistaken for the effect. It would appear that in each case the seaward branch, having attained an extreme northerly position, and the sands bounding the outer end of the main channel being too low effectually to confine and guide the stream, the latter, towards the termination of its prolonged course from the river, becoming diffused, ceased to act as a scour, but tended to give a uniformity of level over the space subject to its more diffused action; the loss of depth in the old channel, gradually effected, at length confined and resisted the stream in this direction, which then was compelled to seek a new outlet to the southward of the point of resistance. The silting up of Formby Channel was therefore rightly attributed to the loss of scour; scour implies certain conditions which involve an exaggerated action of the general current; and, as all changes are derived from the action of the current, the changes it effects will be rapid, or otherwise, in proportion to the strength of the scour, and the resistance opposed by the obstacles with which it meets. To the diminished force of the scour caused by the prolongation of the main channel, will be partly due the increased duration of the more northern channels. The "New Channels" of 1755 and 1833, may not have been actually the first members of each series, but may have been preceded by others more southerly in position, from their proximity to the mouth of the river subject to an increased force of scour, transposing more rapidly the opposing surfaces of their margins, rendering their duration proportionally shorter.[1]

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[1] About the period of the discovery of the New Channel of 1833, writers

It has been attempted to connect these changes with occasional meteorological phenomena,[1] as droughts, freshes, winds; upon the supposition that, by reason of its fickle tenure of locality, such influences are capable of transferring from one situation to another large bodies of matter; but accepting all these as perturbing causes, such constant, gradual, and systematic change as we have witnessed, does not admit of explanation by occasional phenomena.

The hardness of the sands, tested by the lead in sounding, or by a vessel striking on the bottom, agrees with its appearance when dry, and implies a stability of condition, which at first sight may seem contradictory to the definition of "quick sands," often applied to them. Two wrecks, which occurred in November and December 1856, afforded opportunity of observing the action of scour upon the sand, justifying at the same time the definition of "quick sands." One sank on the eastern part of West Middle Shoal, in from nine to twelve feet at low water, the other on Taylor's bank, nine feet dry at low water;[2] in the first case, in three days the wreck had sunk into a basin, bringing her upper deck

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on the subject appear impressed with the idea of rapid change—an idea which also has continued even to our own time. The New Channel was, undoubtedly, short in duration; and if, as I deem it probable, it was preceded by a member or members of still shorter duration, the idea would be amply justified; and it is not surprising that, viewing only the changes then in progress, the disappearance of the South Channel of 1813, and changes in the neighbourhood of the New Channel, which, in our present view, appear in due order, and in obedience to a regular law of rotation, should then have held the aspect of a general convulsion in the surface sands.

[1] "From the foregoing remarks, it appears that the changes in Liverpool Bay are to be attributed principally to the freshes, droughts, wind, and the reduction of tidal area."—*Report to the British Association for the Advancement of Science;* presented at their meeting in 1856, by a committee appointed in 1854 to investigate and report upon the effects produced upon the channels of the Mersey, &c., &c. The committee consisted of the Earl of Harrowby; Sir P. G. Egerton; Sir R. I. Murchison; Admiral Beechey; George Rennie, C.E.; Andrew Henderson, Esq.; Joseph Boult, Esq., Secretary.

[2] The American ship *Silas Wright,* and the schooner *Mary.* Several other wrecks, the remains of which are imbedded in different parts of the sands, would answer the purpose of illustration. The above are selected, as having been from the first subject to my own observation.

nearly to a level with the surrounding sands, the sides of the basin shelving from her up to the original level of the sands, at a distance of about thirty to forty fathoms, with a depth alongside the wreck of thirty-six feet; the second sank gradually into a basin in the same way. A few days subsequently the first was broken up by a gale of wind, leaving only her bottom in the sand, and within a short period all signs of the basin had disappeared; in the second case, the wreck continued to sink till her upper works approached the surrounding level, then the basin gradually filled, imbedding the hull, leaving only a few timber-ends above the surface. Here, in each case, the interposition of a foreign body caused the scour to act upon the sand; but as soon as this body, by being submerged, ceased to offer exceptional resistance to the current, and became, as it were, at unity with the mass about it, the equilibrium was restored, and the sand resumed its dominion. The interposition of these bodies exemplify the action of the current upon the sands themselves. Collectively their specific gravity enables them to oppose the current; but the particles, possessing no cohesion, each unit, in proportion to its individual power of resistance, and specific gravity, is acted upon by the scour in the manner illustrated by the wrecks, each, in the effort to restore the equilibrium, exposing others to the same action, maintaining in unending succession a system of transposition, which may, I think, be not unaptly compared to that molecular motion of water which, in itself infinitely small, effects the undulatory movement of the waves of the sea; similarly the motion of particles of sand modified by the medium in which they move, and the causes that impel them, results in a surface undulation, obeying the impulses of the current.

The effect of some of these impulses we have sketched in their relationship to the termination and renewal of a series of channels: thus far we have observed only those derived from the stream from the river. The general action of the current in the tidal sea, from which our tides are derived, has been clearly laid down; the main current takes a direction from Holyhead to Morecambe Bay, but within ten miles of the shore follows the trend of the land, and near the mouths of rivers takes a more southerly direction with the flood, and more northerly with the ebb. This description from later writers is in effect identical with that of Fearon and Eyes in 1737, who describe the flood tide as entering the Irish Sea at both ends, and flowing towards the Isle of Man and thence toward the Lancashire coast; an oft-refuted but still oft-recurring error treats the subject as if the current of the ocean were a stream which, in its progress entering the Irish Sea, passed Holyhead, and thence onward to Morecambe Bay; whereas the above description implies only the line of direction of the current, which really consists in a comparatively small oscillation of the body of water backwards and forwards, over a space amounting in general at spring tides to from fifteen to eighteen miles, and round headlands and in some eddies becoming twenty-four to twenty-five miles: the former is about the extent of the oscillation off this port.

As effect follows cause, so the river tide is naturally something later in operation than that of the sea whence it is derived.[1] Close in to the edge of the banks the earlier part of the ocean current, whether of the ingoing or outgoing stream, sets on a course governed by the general trend of the land: as the river tide gains strength a tendency to or from the river takes place, the point of deflection at first near the shore recedes seaward, and as the river tide weakens again approaches the shore. This action is modified by the different effects of the river flood and ebb; in either the greatest influence from the river takes place while the sand-banks are covered, on account of the greater volume of water at that time in motion, this is after the first quarter flood and before the last quarter ebb. The ingoing current of the ocean has commenced while the last of the river ebb is still running out, and the sediment brought down by the latter when on the point of settling, is distributed by the ocean stream along the sea face of the banks, and by the first inward tendency of the river tide is turned back on itself. Towards the last quarter ebb the main sands being dry, and the river stream weakened in proportion to the narrowness and shallowness of the channels, the current of the ocean outgoing stream again preponderates, and encroaches upon the outer edge of shoal water conforming to its direction, the river currents in the seaward entrances of the channels

[1] Personal observation.

tending to a corresponding distortion in the deposits subject to their action; the first of the flood contributing to maintain the bar formations, and the last of ebb to the southward tendency of the shoals bordering the seaward entrances of the branch channels, thus assisting toward the gradual increase of divergence from the course of the main stream from the Mersey.

These phenomena explain to some extent the changes in the line of bearing of the channels whose phases we have been considering, which, placing them ultimately across the direction of the current, the undulations of the surface sands are propelled into them, producing their gradual obliteration. In attempting further to develop the causes leading to their northward progression, and to their lengthened duration, we become involved in a complexity of influences, arising from the action and reaction on each other of the currents and opposing sand-banks, and find the actions set up liable to so many perturbations as make considerable deviations in the order of progression inevitable, and must render any attempt to prescribe the locality and duration of features hereafter to be produced by the law of rotation hypothetical.

Changes not less important in their relationship to the general condition of the Estuary, than those developed in the successive appearance and obliteration of these channels, occur in other parts of the Bay. We quitted the Formby Channel of 1736–7 after having observed its separation from the main stream from the Mersey, by the silting up of the passage between Burbo and the Middle Patch, described by John Eyes in 1755, a separation which at the same time severed it from the series comprised in the rotatory system above described: deprived of the effect of scour from the river, its outer portion attained a considerable degree of permanence.[1] We trace it down to 1771 maintaining its general form, but still progressing northward: the Formby Channel of 1813 is probably the remnant of it, and through that it may be traced down to the Formby Channel of our own day. Its outer end shielded from the more rapid effects of the river stream, those effects have been felt in a succession of changes in the neighbourhood of its junction with the main stream, resulting in a gradual decrease of the angle at the incidence of the fairway lines, similarly to that before experienced, which, having attained its minimum, led ultimately to the closing of the connecting channel, and to the renewal of its connection by another, followed again by a similar decrease in the angle of incidence.[1] The chart of 1813 shows two shoal channels connecting the Formby Channel with the main stream, the northernmost of which seems to have attained the minimum above named, and was probably near its close at the time of the survey, followed by the southernmost of the two: the former was totally obliterated at the time of the survey of 1833, the latter closed during the modern period; and Formby Channel, becoming altogether dissevered by high sand-banks from the main stream, took the name of Formby Pool; but again at the time of the latest survey had renewed its connection with the main stream through a narrow shoal gutter.

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[1] The elevation of Mad Wharf, which at this time dried to a distance of five miles from the mainland, by diverting the last of the ocean outgoing stream, contributed no doubt to the permanence of the channel, which in its outward portion remained with little alteration in the surveys of 1755, '67, and '71.

The South Channel of 1813, by its shoaling up, similarly to Formby Channel in 1755, at its point of junction with the main stream, dwindled to the condition represented in the Half tide Swatchway of 1833, and has since been so transformed as to have entirely lost its identity.

It seems probable that the hindrance to the exit of the ebb stream, which in the case of each of these channels led to their deterioration, and contributed to the opening of the New Channels, would influence also the southern portions of the Estuary; but our records do not admit of our tracing closely the effect. In the modern period Rock Channel has been subject to constant change, by the encroachment on its northern borders of the south side of Burbo, until it has almost enveloped "Beggar's Patch," the remnant of the Mockbeggar's Wharf of the former period, and of late years a high lump to the northward of Rock Gut has been gradually moving to the southward into it. East Hoyle has effected a gradual extension of its north-eastern edge, and by closing in on the mainland to the southward, and overlying the site of Hoyle Lake, has fulfilled the contingency prophetically implied in the

[1] *Vide ante*, p. 44.

remarks of Fearon and Eyes on that locality in 1737.[1] Helbre Swash, slightly convex to the westward in its first delineation in 1736, had reversed that condition at the commencement of the modern period, and has since, by encroaching on the margin of East Hoyle, continued to increase its convexity eastward; its south entrance at first westward of Helbre Island has advanced also so as to have attained a position eastward of that island.

These several changes, not less important than those in the northern channels, except in their immediate bearing upon the purposes of navigation, by reason of this exception, and of the slower operation of their changes, attract less general attention, and consequently afford us fewer tangible points for comparison. But if the rotation of the northern channels, accompanied by the advance northward of the north end of Burbo, and the projection in the same direction of Jordan's and Taylor's banks, intimate an approximation to conditions existing about 1736 and 1813, so the gradual advance southward into Rock Gut of the high lump now forming its northern boundary, if continued, will result in a parallel to the description of "East Burbo," by Fearon and Eyes, in 1736-7, "which formerly was high, and divided the channel in two parts;" and also to the similar condition of Rock Channel, exemplified in the chart of 1813.

These facts and probabilities belong to that portion of the bay over which we have seen a certain description of constancy to reign; in another part organic changes have resulted: so large a portion of West Hoyle having gone to the silting up of the Dee, that a return to its former condition seems impossible: an approximation to it, however, is not improbable. It will be observed that East Hoyle, being now united to the main, if Helbre Swash continues its advance eastward, features resembling the Hoyle Lake, Hoyle Bank, and Dove Spit of Collins, will hereafter be produced.

Of the depth to which the process we have been considering may be led to operate, we have little information: from considerations respecting the general nature of the substratum, it is probable that rocky hummocks formed here and there the nucleus of the earliest accumulations, but of the locality or actual existence of such we are ignorant. The changes in the New Channel and Victoria Channel have given us an insight through a depth of about thirty feet of sand over parts of their areas; and similarly we have some knowledge, through Fearon and Eyes's survey of 1736-7, of areas now overlaid by Jordan's and Taylor's banks. Helbre Swash piercing to a depth of sixty feet, through a bank formerly twenty feet above water, evidences a layer of eighty feet thickness of sand there: but of large portions of the bay we have no direct evidence, and can only infer from these examples that the general depth of sand must be considerable.[1]

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[1] *Vide ante*, p. 33.

Lastly, the condition of the land claims our attention; and in entering upon this question great allowance must be made for crudity of execution in the early small charts—the effects of which are magnified, of course, in proportion to the increase of scale in our enlargement. The charts of John Eyes were printed from the plate of the former survey of 1736-7, altered only partially, the land remaining the same. They therefore afford no evidence on the question ; and as, in an operation so slow as that of the interchange between land and sea on our own coasts, it is desirable to have a long period between our points of comparison, I have selected that of a century, between 1736-7, and 1833-5. The land line of the former will be perceived on the chart of the latter date (Sheet 11), traced in a deeper tint; it shews a considerable advance of the land seaward, north and south of Formby Point, and about the embouchure of the Alt, and the encroachment of the sea on the Cheshire shore; while the coast line of the Crosby shore, and the western extreme of Formby Point, have remained stationary.

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[1] The question of depth appears to receive less attention than it demands. In the river, speculations are indulged respecting the removal of Pluckington Bank: of this bank, except where on its outer edge there has of late years been an increase, we have very meagre data as to the depth of the sand. In old maps of the neighbourhood, we find the definition "Pluckington Point," applied to the projecting land south of the pool: at the time of the passing of the act, 8th of Queen Anne, it was stated that the shore opposite the town consisted of rock, covered by a thin layer of sand, extending from 300 to 400 yards from high to low water-mark: this part is now enclosed within the dock walls. It seems probable that the formation constituting Pluckington Point would project, following the contour of the land a considerable distance into the bed of the stream. In the course of the recent works for enlarging the Coburg and Union Docks I observed that about their river entrance the *rock* had to be penetrated in laying the foundation of the walls; how far it may project beneath the sands, and in what degree the Pluckington Bank might be found to resemble or differ from the former strand off the town, it would be interesting to determine. At present it would seem that, though a considerable reduction of the bank, sufficient to remove some of the inconvenience experienced in docking is possible and most desirable, unless we could be satisfied that the rocky strata terminated at the dock wall, its removal in such a way as to become part of the anchorage-ground of the river can hardly be anticipated.

The principal points arising from the preceding considerations are as follows:—

The antiquity of the formations which perplex the navigation of our port, suggested by their relationship to shores whose features have remained constant up to earliest historic ages, and evidenced in the small amount of change to which the general features of the accumulation have been subject throughout the period of hydrographic record, and in particular, as respects the Mersey estuary, in the similarity of measured areas and constancy in general level. On the other hand, in the estuary of the Dee, considerable loss of the outlying sands is accounted for by additional accumulation in the river itself.[1]

With constancy of one description we find associated an equal degree of constancy in another, viz.—a constancy in change: change continuously traced in the northern channels of modern date, and certainly, though not continuously, in those of a former period: the nature of these changes, not fortuitous, but resulting from forces continually operating, the operation traceable in the modern period in effects which imply the guidance of a law, and similar effects indicated in former periods. The nature of the law, evidenced in one region in a northward progression, accompanied by other phenomena, in a manner strongly suggestive of a system of rotation: the operation of the law, subject to perturbations, of the precise effects of which we are ignorant, the period of rotation, therefore, to us uncertain. Changes in other regions of the bay point to effects similar in operation; tending to connect them with those of the northern channels. A cycle of rotation, if represented as has been indicated, by the interval between the conditions described in the chart of 1736-7, and 1813, may be supposed to consist of from eighty to a hundred years; while that period and the rotation it includes, may again have some relationship to the entire accumulation of the bay, of which we are yet in ignorance. Of the depth to which the forces we have contemplated may be led to operate we know little; but may judge the strata of the whole Estuary to a considerable depth to be liable to their influence. And lastly, in the Dee estuary, by reason of organic changes, which have placed certain localities beyond the influence of current, some conditions are placed beyond the possibility of recurrence. A small amount of change, resulting in an opposite effect, by bringing within the current influence small areas formerly constituting part of the Cheshire shore, will have a modifying tendency upon the future conditions of its neighbouring sands in the Mersey estuary.

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[1] A survey of the Mersey, made in 1857, for the purpose of comparison with that by Mr. Giles, of 1819-21, shews the balance of change in that river to be on the side of an increase of depth.

Many projects have been broached with a view to remedy this state of change, proceeding mostly, as I believe, upon false premises; viz., either that of the rapid increase of the sandy accumulation, or its fickle tenure of locality. The first seems entirely controverted by facts; and the existence of a law of rotation implies an action as fixed in its consequences as if the sands themselves were immutable. Throughout our records two principal channels suitable for navigable purposes are evidenced; the constancy of general level applies to their depth, which is throughout represented as nearly the same as at present. The prevailing idea of certain periods applied to newly-discovered channels the term "new channel;" our review of their history shews, that in another sense the term was a misnomer, and that, so far from being new, they were reproductions of causes anciently in operation; and though our information is very far from sufficient to enable us to determine the precise locality or duration of features hereafter to be produced, the history of the past seems to point to a recurrence to conditions under which the Queen's Channel, or more probably a succeeding member of the series, at length attaining the position of the Formby Channel of 1736, or the South Channel of 1813, by terminating the present series will result in a repetition of changes, similar to those which our latest records have so distinctly placed before us, and which there is no reason to apprehend will be less favourable to commercial traffic than those we have experienced.

Since the date of Fearon and Eyes's survey of 1736-7, nearly all of the Liverpool Docks have been established, and other artificial works have encroached upon the river. The continued projection of similar works, rendered necessary of late years a conservative supervision of its tidal limits. It has long been established that the preservation of the depth of the sea channels is dependent upon the force of the current projected through them, a force which is proportioned to the tidal capacity of the inland reservoir of the Mersey; to the maintenance and improvement of that capacity, therefore, modern conservancy efforts have been properly directed. That so little change in general level and area in the Estuary should have taken place in spite of artificial encroachments on the river, affords most gratifying promise for the future,[1] and I venture to think that the labours of years to come will so multiply to our view the causes arising from the action and reaction of sands and currents, and the perturbations to which their governing law is subject, as to confirm the wisdom of the present system of conservative supervision, and to point still to the necessity of seeking information rather than of adopting measures for counteracting them. Without entering upon the consequences likely to result from a disturbance of any law of action, by the establishment on the sands of erections for the purpose of guiding the stream or assisting accumulations, I think that such would infallibly be submerged in the manner exemplified in the case of the two wrecks before quoted, unless founded upon the underlying rocky strata, and of the depth at which that may be found we are entirely ignorant; while watchful therefore to appropriate every fleeting spark of light to future illumination,[1] I believe we may, with confidence of good result, leave to futurity the full solution of the seeming difficulties of the present.

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[1] Much has been written respecting encroachments on the tidal area of the Mersey. The former area, according to the estimate of recent writers, amounted to 40,000 acres, from which is said to have been abstracted 13,000 acres. *Vide* Report to British Association 1856, before referred to. The nature of these encroachments must be distinguished from those which have been effected during the last century and a half in the Dee. There the river for a length of five miles was turned into an artificial canal, constructed on marsh lands formerly bordering the river, and the ancient bed of the river was embanked and occupied as dry land; so that Blacon Head above which Leland describes ships coming to dock, in Port Pool (page 54, vol. 5., Hearne's third edition of Leland's Itinerary), is now separated by pastures for a distance of nearly four miles from the estuary. In the 13,000 acres abstracted from the Liverpool tidal area, are estimated the low land of the Wallasey marshes, nearly 3000 acres in extent, and similar extents of marsh land up the river, in the Frodsham and Ince, and the Cuerdley and Norton, marshes. The major portion of these lands have not been continuously subject to the flux and reflux of the tide within historic times, and that condition must be referred to ancient geologic periods. Their overflowing in modern times seems to have been due rather to freshes from the land than tides from the sea; and their drainage, by rendering the flow of land-water constant and regular instead

of intermittent, has no doubt compensated to a considerable degree for the actual abstractions of tidal water from the Mersey. The river Clyde is an instance in which great and favourable changes in the level of its bottom and tidal action have resulted from artificial works.

[1] The collection in the archives of a public office of the notes and working-plans of recent surveys, will supply hereafter data of such a nature as at the present time we are almost wholly deficient. But of all records those respecting tidal phenomena are perhaps the most important, as any change in them would be the unfailing monitors of great physical changes in the region over which they act. Tidal observations, in their application to the general theory of tides, have always laboured under a disadvantage, arising from the difficulty of distinguishing the effects due to meteorological causes, from those of the great forces which govern them. The self-registering anemometer at the Liverpool Observatory, in conjunction with the self-registering tide gauges, may hereafter be the means of clearing away obscurities at present existing: a self-registering barometer on a similar principle would materially contribute to the same end.